Geophysical Research Abstracts
Vol. 21, EGU2019-13676-1, 2019
EGU General Assembly 2019

From earthworms through soil structure to hydrological processes

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Earthworms create macropores and thereby increase vertical preferential water flow which reduces surface runoff and soil erosion but also may enhance vertical contaminant transport. The macropore density and connectivity, and thereby the hydrological functioning of soils, vary in space and time due to earthworms' burrowing activity and their ability to refill their burrows during drought periods. Our aim was to understand the interplay of soil biota, soil structure, and soil hydrological functioning by linking spatiotemporal information on earthworm activity, soil macroporosity and emerging water flow patterns.
Within the DFG project 'CAOS' (catchments as organised systems), we carried out six field campaigns from May 2015 to March 2016 in the small Luxembourgian Wollefsbach catchment (4.4 km2). During each campaign we performed Brilliant blue infiltration experiments on six field sites (three arable land sites and three grasslands) with five replications each. On each infiltration plot, we dug out horizontal profiles in 3, 10 and 30 cm depth and counted all visible blue-stained and non-stained macropores. We took photos of each profile and converted them to binary images of water flow patterns (stained pixels, non-stained pixels). Earthworms were sampled close to each infiltration plot and determined to species-level.
At the 180 investigated plots we found 0 to 300 earthworms m^{-2} and 0 to 500 biopores m^{-2}. Earthworm abundance and biopore density were both generally higher at grassland than at arable land sites and showed a seasonal decline during the summer months. A significant earthworm-macropore relationship could be quantified using generalized linear mixed models. The binary images of water flow patterns from each infiltration plot were sorted by unsupervised learning algorithms (combination of self-organizing maps and Sammon's mapping) yielding a 2D projection where plots with similar flow patterns are arranged close to each other. Coloring this 2D projection by multiple factors (e.g. earthworm abundances, macropore densities, initial soil moisture or the sampling fields), enabled us to derive whether these factors affect the variability of infiltration patterns. For instance, we could show that the in-field variability of water infiltration patterns is lower than the between-field variability while earthworm abundances do not show such a clear, direct effect on the variability of infiltration patterns.